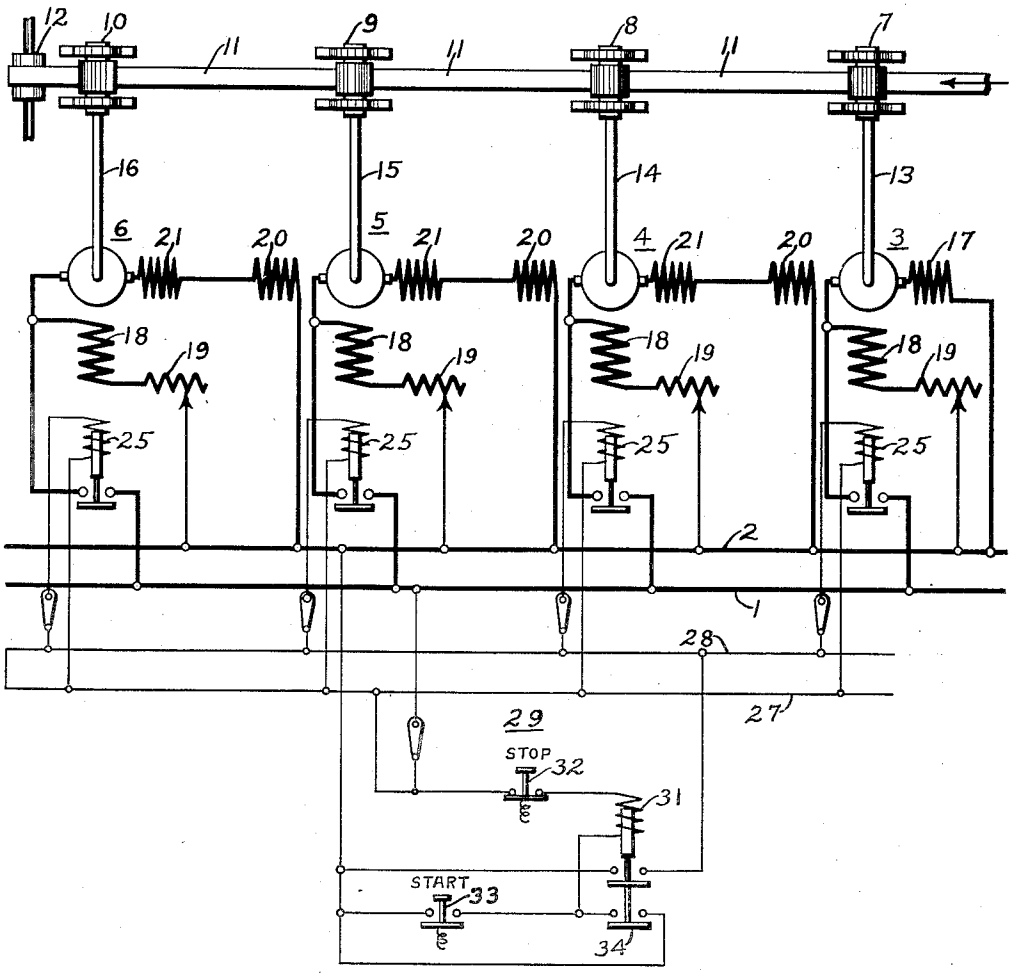
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CONTROL SYSTEM

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CONTROL SYSTEM

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My invention relates to motor-control systems and it has particular relation to such systems as are employed in connection with cold-rolled-strip-mill operations, wire drawing equipment where the wire is reduced in area by drawing through successive dies and the like.

It is customary practice in the steel-mill industry today to arrange cold-roll-strip mills in tandem and have each mill individually driven by a direct-current motor, and the usual practice is, further, to have the tension in the material extending between successive motor stands controlled by hand-manipulated field rheostats.

Because of the variations in roll temperature and in gauge of the entering strip, it is necessary to adjust the field rheostats more or less frequently in order to properly control the loops between stands.

If automatic means were provided to control the speed of the motors, the tension on the strip could be maintained between stands, and manipulation of the field rheostats would be unnecessary.

It is the general belief of manufacturers that the strength and quality of the strip steel is improved by maintaining a uniform tension between the stands, and that the use of the tension enables the operator to use higher rolling speed for a given reduction, thus increasing the production.

One of the objects of my invention is to provide a system whereby the tension upon a continuous stock of material traversing metal-reducing devices or mills is maintained substantially uniform.

A further object of my invention is to provide a system of control, as set forth above, in which the controlling means is automatically operable.

Another object of my invention is to provide a system of the above-described character in which direct-current adjustable-speed motors are used wherein shunt and differential field windings are so arranged that the speed is automatically regulated in accordance with the loads on the successive motors to maintain substantially uniform tension on the piece of material being worked in the mills.

Further objects of my invention will become apparent when considered in relation to the accompanying drawing, wherein the single figure is a diagrammatic view representing circuits and apparatus employed for controlling the mill motors, in accordance with my invention.

Referring to the drawing, a source of energy is indicated by line conductors 1 and 2 for supplying current to driving motors 3, 4, 5 and 6, respectively, coupled to rolling mills 7, 8, 9 and 10 which operate upon the cold-rolled strip 11. The strip 11 is wound, after being rolled, upon a reel indicated at 12. The motors 3, 4, 5 and 6 are coupled to the mills 7, 8, 9 and 10 by any convenient and practical means, illustrated here as shafts 13, 14, 15 and 16.

The motor 3 embodies a series field winding 17 and a shunt field winding 18 which has a variable resistor 19 connected in series relation therewith. A differential field winding 20 is also employed to regulate the excitation. The field winding 20 receives its exciting current from the armature of the motor 4 and is connected in series relation to the series field winding 21 of that motor.

Motor 4 also has a shunt field winding 18 and a differential field winding 20 similar to those described in connection with the first motor 3. The shunt field winding 18 also has a variable resistor 19 connected in series relation thereto for varying the current flowing through it. Motors 4 and 5 have similar field windings and controlling means. Motor 6 is similar to motors 4 and 5, with the exception that, being the last motor in the line of operation, it has no differential field winding 20.

The motors may be connected to supply conductors 1 and 2 by means of relays 25 associated with each motor. The relays 25 are controlled by means of a circuit, such as represented here by conductors 27 and 28, and a control circuit relay 29 is connected in series relation to the actuating coils of the motor relays 25 for transmitting energy from the supply conductors 1 and 2. The control

circuit relay 29 is a common type of relay having an exciting coil 31 in series with a normally closed stop push button 32 and a normally open push button 33 and an interlock 34 for shunting the start button 33 when the relay closes.

Assuming that the apparatus is in its inoperative position, to start the rolling mills, the start push button 33 is closed, causing relays 25 to be energized, which in turn, connect the mill motors 3, 4, 5 and 6 to the source of supply indicated by conductors 1 and 2. When the rolls are started and no material is being worked, the speed of motor 3 may be regulated by the variable rheostat 19 in its shunt field circuit in order that the delivery speed of the first mill 7 shall be approximately 10% less than the speed of the second mill 8, so that, when the strip enters the second mill 8, tension will be established between the mills 7 and 8.

When a metal strip enters the second mill 8, under these conditions, it will be rapidly taken up and put under tension, causing an additional load to be placed on the motor 4 driving mill 8; and a correspondingly increased value of current will flow through the armature of that motor. The armature current also passes through the differential series field winding 20 on the motor 3 associated with the first mill 7 and, as a result of the decreased field strength caused thereby, its speed increases, thereby reducing the tension between the mill 7 and 8 and causing less current to flow through the second motor 4.

It is evident that a balanced condition will be reached when the speed of the mill increases to a value which causes a predetermined decrease in the load and current on the second motor 4. It is also evident that, by adjusting the resistor 19 which is connected in series relation to the shunt field winding of the motor 4, coupled to the second mill 8, any desired tension within the capacity of the equipment may be maintained between the mills 7 and 8.

Any number of mills may be employed and each successive motor may be arranged to operate similarly to the motors just described; that is to say, the operation of further motors, such as 5, associated with the remainder of the mills, as illustrated in the drawing, will be identical with that of motor 4. However, the last motor 6 in the line, which differs in construction as explained above, will, not so operate, and there is no necessity for it doing so.

While I have shown my invention, in a preferred form, as applied to cold-rolled-strip mills, it is apparent that such a system may be utilized in connection with other similarly operated apparatus. As it is also possible that modifications may be made in the arrangement of circuits and apparatus employed without departing from the spirit of my invention, I do not wish to limit my invention to the specific embodiment illustrated, but desired that only such limitations shall be imposed as are indicated in the appended claims.

I claim as my invention:

1. In a control system for a rolling mill provided with a plurality of sets of reducing rolls disposed to operate in tandem relation, in combination, a plurality of variable-speed motors for operating the reducing rolls, said motors being provided with shunt-field windings for controlling the initial relative speeds between roll sets before the stock to be rolled enters the rolls, and an auxiliary field winding for each motor, said auxiliary field windings being interconnected between adjacent motors in such manner as to cause a variation in the field strength of a motor driving a roll set from which the metal stock is issuing in response to a variation in the load upon a motor driving a roll set which is receiving the metal stock, thereby to regulate the tension on the stock between roll sets by varying the speed of the delivering roll set.

2. In an electric drive for a rolling mill for rolling metal stock comprising a plurality of roll sets in tandem relation, in combination, a plurality of motors for operating the roll sets, each motor being provided with a cumulative and a differential series-field winding and a shunt-field winding, a source of power for the motors, said motors being connected in parallel circuit relation to the power source, means for controlling the excitation of the shunt-field windings to regulate the no-load speed of the motors, the differential series-field winding of one motor being responsive to the load current of the next preceding motor, whereby a substantially uniform and predetermined tension is automatically maintained on the metal stock between the roll sets.

3. A control system comprising a plurality of metal-working devices arranged in tandem relation for simultaneous action upon a single length of stock, a motor for operating each metal-working device, said motors having series and shunt field windings, the series-field winding of one motor being connected in the armature circuit of the preceding motor to render the field excitation and speed of said motor responsive to the load on the preceding motor, thereby to cause the speed of the first motor-driven device to vary in accordance with speed of the preceding motor to maintain a predetermined pulling tension on the stock between the metal-working devices.

4. In a control system for a rolling mill having a series of separte roll sets disposed to act simultaneously upon a continuous piece of material, in combination, a motor for actuating each roll set, said motors having interconnected field windings for rendering the field excitation of one differentially respon-

sive to the load on the preceding motor to produce a speed balancing effect between each two motors of the series, and means for varying the field excitation of the motors independently of the load to regulate the initial relative speeds of the series of motors, to be maintained by the interconnected field windings.

5. In a metal-reducing machine in combination, a plurality of metal-working devices arranged in tandem to operate on and advance a length of stock, separate motors for operating the respective devices, each motor having an armature and compound field windings so arranged that a field winding associated with each motor, excepting the last, is excited by the armature current flowing in another motor to maintain a predetermined speed relation between the respective metal working devices regardless of the speed of the mill.

6. In a control system for a rolling mill provided with tandem roll sets for reducing metal stock, in combination, a motor provided with shunt and series field windings and a differential-field winding for driving each roll set, the differential-field winding of the first motor being connected in the armature circuit of the second motor, a rheostat for adjusting the excitation of the shunt-field windings to adjust the relative speeds of the motors in a predetermined ratio for no-load operation, to predetermine the tension to be maintained on the stock between the successive sets of rolls, said differential-field windings being disposed to vary the speed of their respective motors in accordance with the load imposed upon the preceding motor, thereby to maintain the tension on the metal stock between the roll sets at substantially the same value as determined by the shunt field adjustment.

7. A control system comprising a plurality of metal-reducing devices arranged in tandem, an electric motor for driving each of said devices, said motors having armature windings and compound field windings, a field winding associated with each motor, except the last, being connected in series relation to the armature of the next succeeding motor, to cause the excitation of each motor to be responsive to the load on the next succeeding motor and its speed automatically controlled in a manner to maintain a substantially uniform speed of said devices.

8. A control system comprising a plurality of metal-reducing devices arranged in tandem for working a piece of stock, an electric motor for driving each of said devices, each motor having an armature winding, a differential field winding and a shunt field winding, the differential field winding associated with one motor being energized by the current flowing in the armature of the next succeeding motor, and means for manually regulating the current in each shunt field winding to maintain any desired relative speed.

9. A control system comprising a plurality of metal-working devices arranged in tandem for simultaneous operation on a length of stock fed by one of said devices to the other, separate electric motors for actuating said devices, each motor having an armature winding, a series cumulative field winding, a shunt field winding and a differential field winding, the differential field winding associated with each motor being energized by the current flowing in the armature winding of the next succeeding motor and responsive to the load thereon for varying the speed of the corresponding motor to maintain a substantially uniform speed on said motors, and means associated with each shunt field winding for regulating the flow of current therethrough to regulate further speed of said devices.

10. In a control system for a rolling mill provided with tandem roll sets for rolling metal stock, a plurality of motors provided with field windings for driving the roll sets, a source of power for the motors, said motors being mechanically connected to their respective roll sets and connected in parallel-circuit relation to the source of power, one of the field windings of the first motor being interconnected with the armature of a second motor, means for adjusting the initial speed of the motors before the stock enters the first roll set in order to subject the stock to a tension as it enters each succeeding roll set, said interconnected field windings being disposed to vary the speed of the first motor and its roll set in accordance with the load imposed upon the second motor as the stock enters the second roll set, thereby to control the tension on the stock between the roll sets by varying the speed of the motor driving the first roll set.

11. In a control system for a metal-rolling mill provided with a plurality of tandem roll sets, in combination, a plurality of motors provided with cumulative and differential series field windings and a shunt field winding for actuating the roll sets, a source of power for the motors said motors being connected to the source of power in parallel-circuit relation and the differential series field of one motor connected in the armature circuit of an adjacent motor whereby the speed of the motors is automatically varied in accordance with the loads on the respective roll sets to maintain a predetermined tension on the metal.

12. In a control system for a metal-rolling mill provided with a plurality of tandem roll sets, a motor provided with shunt and series field windings and differential field windings for driving each roll set, the differential field winding of the motor driving the first roll set

being connected in the armature circuit of the motor driving the second roll set, a rheostat for adjusting the excitation of the shunt field winding to adjust the relative speeds of the roll sets before the metal stock enters the first roll set to determine the tension to be maintained on the metal stock between successive roll sets, said differential windings being disposed to determine for given load conditions the relative speed of the motors driving the successive roll sets.

In testimony whereof, I have hereunto subscribed my name this 28th day of March, 1927.

DALE W. DEAN.